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THE POWER RESOURCES OF THE SOUTH[1]

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Nature, before man's advent, marked the southern states region as the home of water powers. The distinguishing natural characteristics of this region are the very ones which produce numerous and great water powers and foster industrial conditions, making feasible their useful application. Consider the copious rainfall with good seasonal distribution; massive lofty mountains, remote from the sea coast, covered densely by unbroken forests for the rain to fall upon; favoring topographical conditions under which impounding reservoirs are practicable along the tributaries; and geological action, so universal in effect that every great river, as it flows with its gathered waters through the lowlands, comes to a place where it tumbles down over a rapidly descending bed. Note the exceptionally favorable climate; peculiar meteorological conditions, and a soil which seems to assure to the region a world monopoly of a universally necessary natural product requiring cheap and plentiful power for its fabrication; majestic rivers navigable almost to the mountain base; timber, iron and coal in great abundance and disposed for cheap production; and everywhere the sea close at hand to the industrial section.

Barring the shore line of the Pacific in Washington and Oregon, and a still narrower strip along the summit line of the Sierras in California, and that of the Cascades in Washington and Oregon, the whole of the United States west of a north and south line drawn through central Texas may be considered as arid, the greater portion of it having a mean annual rainfall approximating fifteen inches. Extending in a north and south belt 200 miles wide through central Texas, Oklahoma, Kansas, Nebraska and the Dakotas is the semi-arid region, the greater portion favored with rainfall averaging less than twenty-five inches per annum. East from this, extending to the Atlantic, is the great humid region, within

[1]A paper read before the Southern Commercial Congress at Washington, D. C., December 7, 1908.

which, however, there are greater differences of regional rainfall than exist between the different grand divisions themselves. The northern half, being really semi-humid, has thirty to forty inches rainfall, while the southeastern portion, bounded by a line extending from Galveston on the Gulf coast, north to central Arkansas, then east to northeastern Georgia, thence northeast to southeastern Kentucky, thence east to the Atlantic coast, constitutes the true humid region that has fifty inches to sixty inches precipitation, while the mountainous portion thereof in east Tennessee, western North Carolina and South Carolina, northwestern Georgia, and northeastern Alabama, together with a narrow strip along the Gulf of Mexico, shows the extraordinary average of sixty inches to seventy inches of rainfall per annum.

Even this striking superiority in rainfall does not directly convey an adequate idea of the superiority of southern water-power possibilities, for it is the volume of water which actually finds its way into the streams that determines the measure of power, and this may be less than two per cent of the precipitation in a region of twenty inches average rainfall, and may exceed fifty per cent of the precipitation in a region of sixty-five inches average rainfall.

A realization of these exceptional meteorological phenomena coupled with the unparalleled surface conditions comprised in the towering mountain masses of the Southern Appalachians covered with close set hardwood forests, nurtured in their birthplace, impels the mind to the belief that here is the spot nature selected to foster man's efforts to transform to his uses the exhaustless energy of falling water.

Relation of Water Power to the Future of the Race

How are we to interpret the modern consuming industrial activity of civilized peoples? Is it a phase approaching the zenith to pass and be interpreted by future generations as important only in that it was one more historical epoch, contributing much of value to the world, but from the excesses of which man recoiled, setting his ambitions to something more worthy? Or will the evolution follow an ever-ascending curve of material accretion into an indefinite future? Upon the answer depends in part the relation of water powers to the future of the race.

An industrial age of necessity, first and foremost, must be an age of power transformation. Increased production of raw materials involves the use of more power in winning them from their primal condition. More manufactured products demand more power for their fabrication. Greater activity in transportation is at the expense of more power. The growth of cities with their electric lights, water supply and transportation systems, increases greatly the per capita demand for power. To whatever degree may grow production, transportation and the enjoyment of material comfort, to even a greater extent will grow the use of power. But power development to-day has one ominous significance, for it is effected most exclusively by the consumption of a waning supply of coal.

For the first time in the ages that man has occupied the earth it dawns upon his quickened intelligence that the cunning of his brain and the strength of his hand unrestrained and unintelligently guided tears down more rapidly than nature restores, and that it is high time for the civilized people of the earth to safeguard their natural resources against inevitable and lasting destruction. What is the way out? How shall leaping demand be met by a waning exhaustible supply? Intelligent forestry will insure the timber supply indefinitely. The fixation of atmospheric nitrogen, intelligent manipulation of crops and preservation of soil covering will maintain the food supply. The use of various synthetic substances will relieve their natural prototypes. The application of Portland cement as a structural material in new fields, the growth of water transportation possibly at the expense of railways and the wider use of other metals and their alloys, may put forward the dearth of iron indefinitely. But every tendency is toward the increased rather than the diminished use of power, and how shall the burden be shifted from coal to some other source of energy?

Here, then, is the aspect in which water powers present their profoundest importance. They are the only known future great sources of power in an age shackled to an increasingly lavish expenditure of power.

Water Powers as Natural Resources

Water powers, considered as a natural resource, have one distinguishing characteristic—they waste only in their non-use. Every

year of idleness means the exhaustion of a comparable amount of coal and iron, and the loss of potentially useful energy that can never be recovered.

Water powers are eternal, and will exist as long as the sun shall shine, and moisture is evaporated, transported and lifted by wind, congealed by cold and pressure, and precipitated upon the land by gravity. Indirectly but none the less disastrously, however, man can ruin the utility of water powers by destroying the forests which store the rain at the stream sources, protect the surface from erosion, and the valleys and reservoirs from deposition. The useful application of water powers may be marred or prevented by the prior vested rights of railways or other structures occupying land needed as sites for dams, reservoirs, or conduits, by the construction on river banks of lateral canals for navigation, or by the initial construction of works which, while providing for only partial development of the full potential power of the stream, or by reason of faulty design, are incapable of expansion or additions within limits of reasonable expense and bearable sacrifice.

The Relation of Government to Water Powers

There is much misunderstanding of the nature and degree of federal control of water powers. The fact that powers on unnavigable streams in no manner fall under government supervision, is generally understood. But it is a common fallacy to suppose that powers on navigable streams are owned by, or in some manner are administered by, the government at Washington.

The United States of America, organized by the thirteen original sovereign states, possess only such powers and authority as were expressly conferred by the constitution. The relation of the federal government to streams rests upon expressly conveyed power "to regulate commerce with foreign nations and among the several states and with the Indian tribes." All other properties and functions of navigable rivers, apart from those involved in the regulation of commerce, their beds, the potential energy of the water and the water itself, and all properties of unnavigable rivers are withheld by the several states unto themselves, and this has been frequently affirmed by the supreme court. As conservator of navigation, the federal government can restrain any state or citizen acting under authority of the state from using the bed, transforming the

energy of the water, or otherwise using state or private property on a navigable stream, if the contemplated use jeopardizes navigation. Furthermore, constitutional prohibition restrains the national government and many of the states from engaging in the commercial enterprise of owning and constructing water power works.

The problem of preserving to the people their equities in natural resources including water powers will soon have to be met. Are private corporations to enjoy sole possessorship thereof in perpetuity? At the present time, in the absence of substantial cooperation by the government in the initial expense of development, the investor will be deterred from risking his money unless the entire resulting profit for all time is to be his exclusively. The fact that the national government and some states are preserving forests at the sources of power streams, a necessary step to their permanent use as such, is pertinent as bearing upon the possible limitation of private ownership in water powers.

The Government of Ontario, Canada, is to become a purchaser of Niagara power on a grand scale, and will distribute and sell. Sweden both leases and develops its powers. The smaller political divisions of Norway build and operate powers, while Germany, as well as other countries, collects power royalties from users of streams.

It is not unreasonable to anticipate that greater control, and possibly the actual exploitation, of water powers may become a recognized function of our less paternal government. This would require constitutional sanction to be true, and in the meantime, we may expect to see much ingenuity exercised by the federal government, under the pretext of conserving navigation, both in wise restriction of private water power enterprises on navigable streams, and in some manner contributing to the success of other power developments whose beneficial effect will be sufficiently far reaching.

To the Southern States such considerations are all important, for a large part of their immediately available water powers are on navigable streams, and already on two of her greatest rivers the development of power awaits favorable action by the government relative to problems in navigation.

Advantages in the Use of Water Power

Water power is universally transformed into electrical power. Converted and transmitted as such, the horizon line within which

it may be practically applied stretches away 100 to 200 miles from the hydraulic station, and, with time and improvements, will be much farther.

The relative direct costs of power production by hydro-electric and steam plants are as various as the possible combinations of elements which enter into each and the places and peculiarities of power demands. For instance, where power is required at a uniform rate throughout a twenty-four-hour day, as is the case in many milling and electro-chemical industries, water power, on account of its cheapness, is the only possible source of energy. On the other hand, if the use of power is great and covers a period of ten hours daily, fuel is good and cheap, and high economy boilers and engines are employed, steam not infrequently may be used as cheaply as hydro-electric power, particularly if the latter is transmitted over a distance. In hydraulic plants where the natural delivery of the stream is relied upon without the aid of storage it may cost practically no more to develop a twenty-four-hour horse power than a ten-hour horse power; while in the case of steam plants one may be double the other. A fair idea of the comparative direct costs of steam and hydro-electric power is conveyed in the statement that eleven-hour steam power costs in the South $20.00 to $60.00 within the ordinary range of fuel prices, effectiveness of different types of boilers and engines, hourly and monthly variations in demands for power, capacity of plants and effectiveness in management. Hydro-electric eleven-hour power costs correspondingly for generation and transmission $12.00 to $24.00. None of these figures represents extremes. The price paid by the customer per horse power delivered by the hydro-electric company may be depended upon to be ordinarily fifty per cent to seventy-five per cent of the direct cost of its generation by the independent steam plant.

Critical analysis of the advantages accruing to the user of hydro-electric power is possible only in the light of industrial requirements governing modern manufacturing industries, where the absorbing ambition is to produce and market the maximum volume at the lowest cost per unit of product. Hence we find differences in direct cost of power are relatively unimportant except in industries where the great use of power makes it a principal factor. Of greater importance are considerations involved in the application of power.

The use of electric power purchased of a distributing company is in consonance with that fundamental tendency of modern manufacturing toward the subdivision of labor and concentration on the fewest possible operations, removing the independent steam plant with its many complications from the solicitous care of those to whom power transformation is only means to an end.

The impossibility of restricting the delivery of hydro-electric power by adverse combinations of labor or capital affecting the source of energy and complete independence of railways and their physical limitations in the delivery of fuel and the fixing of transportation rates therefor, contribute to certainty and uniform conditions of power supply. The elimination of the multitudinous parts of a steam plant subject to incessant renewals makes for a minimum of interruptions. A recording electric meter placed upon each significant operation of a mill enables that differentiation and comparison of activities necessary to an intelligent improvement in the economics of production. There is saving in ground and floor space, frequently not to be had in case of required additions to steam plants; ability at all times to meet increased demands for power without delay or measurably increased investment therefor, and no necessity for power plant extensions, the capacity and cost of which may be wholly out of proportion to the increased demands for power.

Soft coal smoke has been a necessary evil accompanying the blessings of prosperity. In industrial communities it vitiates the air and thus is hygienically bad, obscures the sun for days, thus depressing the spirits and the play of the imagination, and burdens the people with the support of the thousands of cleaners of one kind and another. We may never know to what civic pride we might have attained, and in what exquisite homes, gardens, architectural structures, furnishings and decorations we might have expressed that pride, could they have been free from the black destructiveness of coal dirt. It is only those communities wherein "white coal" shall turn the wheels of industry that may hope to deserve the appellation of the "Sunny South."

Commercial Limitation of Water Powers

The business of transforming and distributing hydro-electric power is one requiring usually large investment, and is an extreme

type of that class of enterprises in which the first investment is wholly out of proportion to the initial demand for the product and the resulting income. The operating expense, maintenance and depreciation of any plant are usually minor considerations, compared with the fixed interest charges, and are practically independent of the amount of power generated and transmitted. These are the all powerful factors influencing the practices of water power companies and their relation to the public. Companies are forced to search for large power consuming industries to be installed coincidently with, or quickly following, the completion of the power plant, and to such customers, power is sold at extremely low rates to be balanced later by sales at higher rates for superior uses. Consequently, the effect is to introduce to the locality new industries and later those which consume their products or provide their wants, which, were it not for the presence of developed power, never would have become established there by any possibility.

Such conditions are the explanation of, and defense for the contention that rates for the government of power companies should not be fixed by legislation. They also in part explain the advantages that result to the community by restricting the business of power generation in any section to a single company, for, without the promise of later high-priced business to support the large output of low-priced power, there would be no sufficient inducement for the projectors. With more than one company in the field, this adjustment of rates would be difficult, if not impossible.

Interest on investment, sinking fund, management and depreciation are the chief, and frequently the only measurable operating burdens, and all within wide limits may be independent of the amount of power developed and marketed. Consequently, the greater the output of power by any company, and as a corollary the fewer the companies in any field, the cheaper the unit of power can be produced and marketed.

Greater utilization of this exhaustless natural resource, conversely less waste; cheaper production and more reliable service are the merits which tend to make the single water power development a beneficial monopoly in any district, and it would seem as if natural commercial exigencies beyond the control of the corporation guaranteed minimum rates for its patrons.

These severe limitations and very unusual conditions have

made of water power development a business peculiar to itself. That this has been too little appreciated by the pioneers of the industry is well reflected by the statement of an officer of the Engineer Corps, United States Army, that in his examination of water powers as investments, he never had found the man who for the second time was an investor in this class of securities.

It is to be hoped that government officials whose co-operation is necessary to the development of water powers in the South will be keenly appreciative of these restrictive commercial peculiarities, and be governed accordingly, the fact being that to a great extent in the South, power enterprises, particularly the larger ones, must be exploited in regions where the industrial advantages are chiefly potential, and responsibility for the prosperity of the section rests upon water power development, and the ability and determination with which it may be prosecuted.

Physical Limitations of Water Powers

Work is the product of force by the distance through which force acts. Energy is the ability to perform work. Force in the case of water powers is represented by the weight of the water, and consequently the flow, while distance is represented by the vertical space through which the water drops, and consequently the fall or head. The layman frequently analyzes the physical features of a water power no further than this, but these to be practically utilizable must possess many favorable attributes. The flow must be copious, depending on the area of the watershed and the amount of annual rainfall. It must approach uniformity in some degree, secured by favorable seasonable distribution of rain storms, or by natural or artificial storage. The stream fall at the site of power developed should be great within a limited distance. The topographical conditions at the power plant site should lend themselves to the construction of a regulating reservoir at least large enough to accommodate the day and night fluctuation, and to the construction of hydraulic works, such as dams, conduits and tail races, within permissible limits of expenditure. Where regulating or storage reservoirs are a necessary feature of any development, the stream must not carry silt sufficiently gross to fill or encumber these.

Irregularity of flow, yearly and seasonal, is possibly the commonest and most discouraging limitation. It is low stream flow, as

distinguished from average high flow that measures the amount of power which it is practicable to develop. Consequently, any characteristic of a watershed which may be utilized for, or contribute to, raising or extending the seasonal minimum, reducing the severity of drought has the highest possible value. Here intervenes the incalculable benefit of forests, for they are the greatest and practically the only natural reservoirs for rainfall. Furthermore, by protecting and fostering soil covering, and withholding floods, they prevent the burdening of the streams with silt, thus contributing directly to the feasibility of artificial reservoirs.

Proximity of the water wheels to the place of application of the developed energy was the ancient limitation of a water power, the maximum distance being the span of a leather belt. To-day it is fixed practically by only a single factor, namely, the permissible expenditure for an electric transmission line, the resistance and losses of which shall be within the limits of good regulation, say ten per cent. One hundred and fifty miles is becoming an ordinary maximum. The projected enterprise on the Zambesi River, South Africa, contemplates transmitting from Victoria Falls to Kimberly mines, 600 miles.

We shall see later, in considering the attributes and distribution of southern water powers, that as a rule they possess favoring physical conditions to a remarkable degree, and though remote from centers of industry, we have the satisfaction of knowing that this handicap is one of degree, and is yearly becoming less restricted.

Southern Water Powers

The Census Bureau reports as employed in all manufactures during the year 1905, 14,500,000 horse power. The Secretary of Agriculture in a late report states that the estimated utilizable water power, based on the minimum flow for six high water months without storage, is 5,000,000 horse power on the streams proceeding from the Southern Appalachian Mountains, one-tenth of which has been developed. This by others is estimated to be equivalent to two and one-half times the present developed water powers of the whole United States and half the total undeveloped utilizable water power, and probably even this vast amount of potential power could be doubled by storage. Assuming an average developable capacity of 1,250 horse power, the southern powers would number 4,000. It

is clear that anything approaching a description of, or even a definite reference to, particular water powers, with such a vast number to deal with, is wholly impracticable in such a paper as this. The only suitable presentation is to analyze the broad distribution of these powers, and to treat any particular district as of importance only when such universally favorable conditions for the development and use of power exist as will probably determine the future industrial life of the region.

Water power sites may be said to have a habitat like wild animals. They may be searched for intelligently, as the sportsman hunts mountain sheep among the crags, bear in the canyon, elk and caribou close to the timber line on the long powdery snow-covered reaches of the plateaus. Geology bears a relation to distribution of water power sites, comparable to the effect of climate in determining the natural abode of wild animals. Rainfall is comparable to the flora.

From the Cumberland plateau and the lofty Appalachians with their generous rainfall, the waters flow west, south and east, in tiny rivulets to make larger streams; these flowing together to make the great rivers. Everywhere these rivers descend abruptly and with great volume from the hills to the level stretches of the lower lands, and here is where are to be found the greatest water powers. Far above these so-called "shoals" in the mountainous headwaters, the precipitous stream beds and small tributary watersheds account for numerous small powers. Below the shoals or "fall line" the rivers in great volume flow placidly over the flat coastal plain and no powers are possible. The happy combination of great volume and ample fall occurs at the fall line. From these considerations, it might be foretold that the Mississippi River south of the Ohio is not a power stream. As a matter of fact, there are no power sites south of Keokuk, Iowa.

The tributaries entering the Mississippi River from the west, where they lie within the southern states may give an occasional water power site under favoring local conditions, but there are no universal opportunities for available water powers. Turning now to the eastern tributaries of the Mississippi, we may exclude the Ohio from consideration here, together with its network of streams above the confluence of the Cumberland and the Tennessee, because it barely touches the rim of the region under discussion, and does not present there any strong water power characteristics.

At the Cumberland, however, we enter the abode of water powers, which includes all that region in southeastern Kentucky, the eastern half of Tennessee, the northeastern half of Alabama, the northern half of Georgia, the western half of the Carolinas and all of Virginia, save the eastern portion.

Within this area with their tributaries as a rule heading in the mountains and in part taking rise in the high plains which everywhere fringe the mountains are the great power streams, the Cumberland, Tennessee, Coosa, Tallapoosa, Chattahoochee, Ocmulgee, Oconee, Savannah, Saluda, Broad, Wateree-Catawba, Pee Dee, Roanoke and the James. These segregate naturally and by industrial requirements into three main power districts which may be termed western, southern and eastern. The first is as yet wholly undeveloped and lies about the South's great iron and coal district, the seat of which is Birmingham, Ala. The second is already well exploited and lies along the Chattahoochee from Columbus, Ga., north to Atlanta. The third is the most fully realized, a third of the easily available power being already developed. It lies in the favored agricultural district of northern South Carolina and southern North Carolina, stretching north from Columbia 200 miles. The Saluda, Broad and Wateree-Catawba rivers are its principal sources.

The Cumberland's main stem in southeastern Kentucky and the Caney Fork tributary in central Tennessee are good power streams. It is practicable to develop 20,000 to 30,000 twelve-hour turbine horse power at a single site on each. Cincinnati, Louisville and Chattanooga are 125 to 150 miles from one, and Nashville, Huntsville and Knoxville sixty to seventy-five miles from the other.

The Tennessee River is synonymous with water power. Where the three great rivers, the Ohio, Cumberland and Tennessee, join, the Tennessee is credited with contributing from an area almost as great as England a volume of water as great as the Ohio and Cumberland combined. The topography of the upper watershed lends itself to the construction of numerous great reservoirs at permissive cost. According to the United States Geological Survey, this river and its tributaries, French Broad, Little Tennessee, Clinch and others, possess a third of the available water power of the entire Southern Appalachian Mountains, beginning with the Potomac River on the east, and taking in all the great streams entering the

Atlantic, the Gulf of Mexico and the Mississippi, around to the Cumberland River on the west. In storage possibilities it possesses alone more storage capacity than all the other streams and their tributaries combined. The total potential power of the system, estimated on the basis of the minimum flow for six high water months during the past seven years, is 1,000,000 turbine horse power. It is believed that practicable available storage will enable this to be more than trebled ultimately.

At Muscle Shoals, close to the fall line, in northwestern Alabama, with tributary watershed of 29,000 square miles and 10,000 second feet minimum mean fortnightly flow, the river tumbles down 130 feet in thirty miles between high rock walls, a foaming shallow mass of water one and one-half miles in width. The development and transmission of 100,000 twenty-four-hour horse power delivered to the customer at a remote distance is here practicable without stream regulation. With storage capacity to the amount estimated to be ultimately available, a total generator installation of 500,000 horse power will some day be practicable.

The Tennessee River breaks through the Cumberland plateau at Hale's bar below, and thirteen miles from Chattanooga, and here is now being installed a hydro-electric plant of 50,000 horse power. A great number of valuable power sites are to be found on the tributaries of the Tennessee where they ramify and cover practically the whole western slope of the Southern Appalachians. A notable example is on the Little Tennessee, forty miles from Knoxville, where an available head of 175 feet is securable, and an installation of 30,000 to 40,000 horse power practicable.

One has only to follow the fall line to encounter many valuable water powers in Alabama. These belong chiefly to the Alabama River drainage, emptying at Mobile, and are not all properly Appalachian streams, although for the most part their sources are in the extreme southern slope of these mountains.

Wetumpka on the Coosa and Milstead on the Tallapoosa, fifteen and thirty miles respectively from Montgomery, mark the intersection of these streams with the fall line, and for miles above occur the finest power sites in Alabama south of the Tennessee River.

The Coosa River above Wetumpka falls 367 feet in 142 miles, and the run-off data indicate that on the basis of a sixty per cent

load factor, and without impounding more than is locally practicable at the power house sites, the stream is capable of accommodating about 100,000 horse power of generating machinery. However, any project here is complicated by the fact that the Coosa is a navigable stream, and has been only partially dammed and locked by the national government.

The Tallapoosa River has a watershed of nearly 4,000 square miles above Milstead. There are two power plants three and one-half miles apart working under a total head of 100 feet, while seven miles farther above there is an available power site where the erection of an impounding dam makes practicable a head of 120 feet. The opportunity here for storage is almost unexampled, and makes available within this short stretch of river, as the result of careful computation, based on many years' stream gaugings, the great total of 100,000 eleven-hour horse power transmitted to the consumer.

A mere summary of the physical conditions surrounding the Chattahoochee River is sufficient to indicate its possibilities. It crosses the fall line at Columbus on the boundary line between Alabama and Georgia, above which point it has 4,900 square miles of watershed, and a mean minimum fortnightly flow of 2,000 second feet. From West Point to Columbus, thirty-five miles, the river falls 362 feet, flowing for a large part between high rock walls relatively close together. Practically fifty per cent of the available power of the entire system may be developed on this section of the river. The strikingly favorable features do not end here, for 140 miles above West Point are admirable power sites, notably those in the neighborhood of Bull's Run. It is not astonishing then that this stream should be one of the best exploited in the South. The present installations employ 200 vertical feet. Columbus, at the head of navigation, styling itself the "Electric City of the South," has many cotton and woolen mills. Atlanta relies chiefly on this river for its light and street railway uses. Geological Survey estimates credit the Chattahoochee with 230,000 potential turbine horse power on the basis of six high months' minimum.

The Flint, Ocmulgee and Oconee rivers cross the fall line in central Georgia; the two latter, at Macon and Milledgeville respectively, have limited watersheds and do not take their rise in the mountains, but possess relatively steady flow and good power sites. The former has shoals all the way down to Albany.

Georgia's eastern boundary, the Savannah River, is even a greater power stream than the Chattahoochee, forming a part of the state's western boundary. It leaves the archaic rock at Augusta, to which point is tributary 7,200 square miles of watershed, and a mean minimum fortnightly flow of 4,200 second feet. Augusta was at one time the third city of the Union in the use of water power, the municipality having begun its development as early as 1845. To-day it is one of the great cotton manufacturing centers of the world, appropriating approximately 24,000 horse power to this service. Seven miles above the city a ten-foot dam delivers to a canal which provides forty-five feet head at the mills.

Within a distance of ninety-three miles above the dam, there are seven power sites on the main stream and tributaries, employing 383 feet of fall. A carefully studied plan for their utilization provides for installing generator capacity of 150,000 horse power. Engineering skill of a high order prepared the project and it is interesting to note that the proposed installation of 150,000 horse power is practically equivalent to the Geological Survey estimates of turbine horse power on the same stretch of the river, based upon the minimum of six high water months, namely, 139,000 horse power.

If we credit the Savannah River to the State of Georgia, there is left as strictly South Carolinian, only one great power stream, namely, the Santee. This is due to the fact that the fall line crosses the northwestern part of the state, interesting herein only the tributaries of this one Appalachian stream. The Pee Dee flows for the greater portion of its length in South Carolina, but enters the state only sixty feet above tide level.

The region from Columbia north for 200 miles, a belt of approximately 150 miles in width, including roughly equal areas in northern South Carolina and southern North Carolina, is at once the greatest water power and the greatest cotton manufacturing region in the South. Here are manufactured one-half of the southern cotton goods. Above Columbia, marking the fall line, there are 4,800 square miles of watershed on the Broad River with estimated 130,000 turbine horse power and 2,300 square miles on the Saluda, credited with 60,000 turbine horse power. On the Broad at and above Columbia, 25,000 horse power is developed at three sites, on a total head of eighty feet, supplying cotton mills chiefly. Four

new enterprises are projected, employing 180 feet head, for a total development of 60,000 horse power. There still remain 250 feet head unappropriated on the main river with substantial area of watershed available. On the Saluda 25,000 horse power is developed at six sites, with a total head of 200 feet, used by cotton mills far and near. Two new plants are projected for the development of 15,000 horse power on an 80-foot head. Nearly 500 feet of head as yet is unexploited within the limits of substantial flow.

Camden, the fall line of the Catawba or Wateree River, with 4,400 square miles tributary water shed, lies near the foot of shoals which descend sixty-five feet in six and one-half miles, capable without storage of development of 20,000 turbine horse power. The stream above will be able ultimately to accommodate 150,000 horse power of generating machinery without stream regulation, and one corporation alone owns five valuable power sites with 262 feet total head in this stretch, two of which have been developed for long distance transmission to the mills of the surrounding region. There are left in the practicable portion of the river only 100 feet unappropriated.

The Yadkin River powers naturally should be considered in connection with the tributaries of the Santee just reviewed, for the reason that together with them, it is favorably situated to foster the same cotton mill section. Above Cheraw, S. C., the head of navigation, the river has a fall of approximately 600 feet in 120 miles. In this section occurs eighty per cent of the total developable power of the stream and tributaries, namely, 100,000 horse power minimum. In this section are the Narrows, which in some respects mark the most striking water power site in the State of North Carolina. The Tar, Neuse and Cape Fear are not Appalachian streams and do not possess such strongly marked power characteristics as to warrant reference here.

At Weldon on the Roanoke are combined commercial and physical advantages which make this point one of great merit for power development. The tributary watershed is 8,200 square miles with mean minimum fortnightly flow of 4,000 second feet. The storage opportunities on the upper portion of the river and its tributaries are excellent. Above Weldon the stream falls eighty-four feet in nine miles, and two companies have constructed hydraulic works covering practically the whole head, capable of

developing 16,000 horse power. The section of the Roanoke River between Weldon and Clarksboro, Va., at the junction of the Dan and Staunton Rivers, a distance of seventy miles, and a fall of 250 feet, embraces three-quarters of the power possibilities on the Roanoke River, and should warrant ultimately the installation of 100,000 horse power of generating machinery.

The James River in Virginia is the remaining water power stream of strictly southern significance. The best portion is immediately above Richmond, where, with a drainage area of 6,800 square miles, and a fall of 125 feet in fourteen miles, one-third of the total power of the stream may be developed. At Richmond, under a head of approximately twenty-five feet, about 20,000 horse power of generating equipment is installed. The topography of the watershed is favorable to the establishment of reservoirs, and this fact and the presence of many favorable power sites, and the excellent section of country through which the river flows, will no doubt combine to make the James one of the great power streams of the future, whereon may be realized the limits of its capacity, say 250,000 turbine horse power. The mountain tributaries, of all such streams as have them, possess many small and a few large power sites notably in northern Georgia.

The water power region of the South is a vast empire, great in natural advantages. It is a land of opportunities in manufacturing as in agriculture. The productive capacity of the people is great when once they become industrial factors, but their numbers are few. The possibility, indeed the certainty, of development in the South, that many of us will live to see, is suggested in the following comparison between two great power sites, one where works of 100,000 horse power are under construction on the Susquehanna River in Pennsylvania, the coal and iron state of the North, and the other on the Tennessee River in Alabama, the coal and iron state of the South. Respectively they have 27,400 and 29,000 square miles drainage area, 610,000 and 508,000 second feet flood discharge, 2,700 and 8,500 second feet absolute minimum flow, fifty feet and 120 feet net head available for the turbines; the one has torrential floods and no forests about the headwaters, the other has relatively gradual rises and a forested watershed; all to the relative advantage of the southern power. But, in respect to the industrial conditions, a circle of 3,600 square miles about the Pennsylvania site includes

over 2,000,000 people and 750,000 horse power in steam plants, and a circle of 7,500 square miles about the Alabama site includes less than 350,000 people and 70,000 steam horse power. In short, the one section, as compared with the other, employs sixteen times as many people and uses twenty-two times as much horse power per square mile.

Is this relative condition in the South to be interpreted as discouraging? No, for it will change, and change rapidly. The South to-day compared with the rest of the country of twenty-five years ago is producing as much pig iron, mining twice as much coal, has more miles of railway, greater value in farm products, equal value of exports and sixty per cent as much capital invested in manufactures. Southern commerce has grown fifty-six per cent in five years. In this inevitable and swift industrial growth lies the message of southern water powers to the world at large, for not only will their exceptional qualities speed this growth, but the increase of industries will react to produce new incentives to the greater and still greater development of this great resource. Herein lies the interpretation of southern water powers.